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United States Patent [19]

Bartow

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[45] **Date of Patent: Jul. 27, 1993**

[54] **CONTROLLED APPARATUS FOR PAINTING VEHICLES**

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[73] Assignee: **Honda of America Manufacturing, Inc.**, Marysville, Ohio

[21] Appl. No.: **606,081**

[22] Filed: **Oct. 30, 1990**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 575,672, Jul. 31, 1990, abandoned.

[51] **Int. Cl.**[5] **B05C 5/00**
[52] **U.S. Cl.** **118/694**; 118/315
[58] **Field of Search** 118/315, 324, 326, 620, 118/694, 309

[56] **References Cited**

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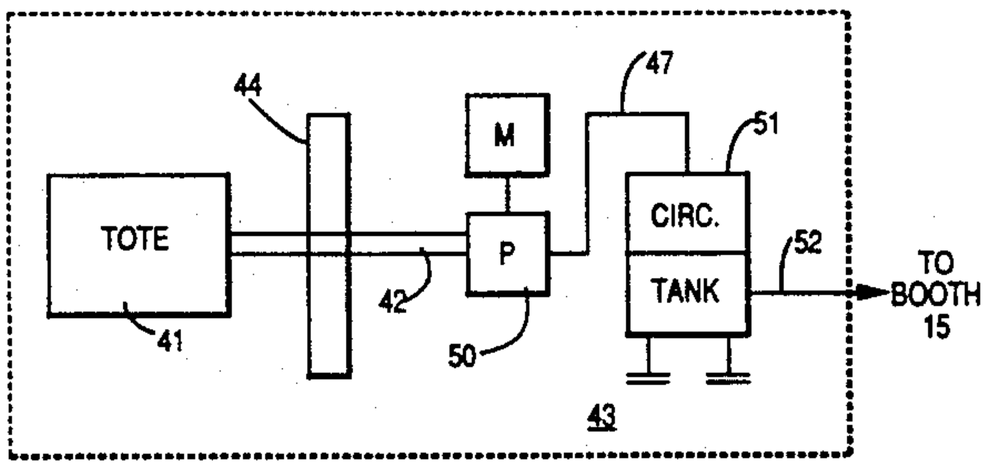
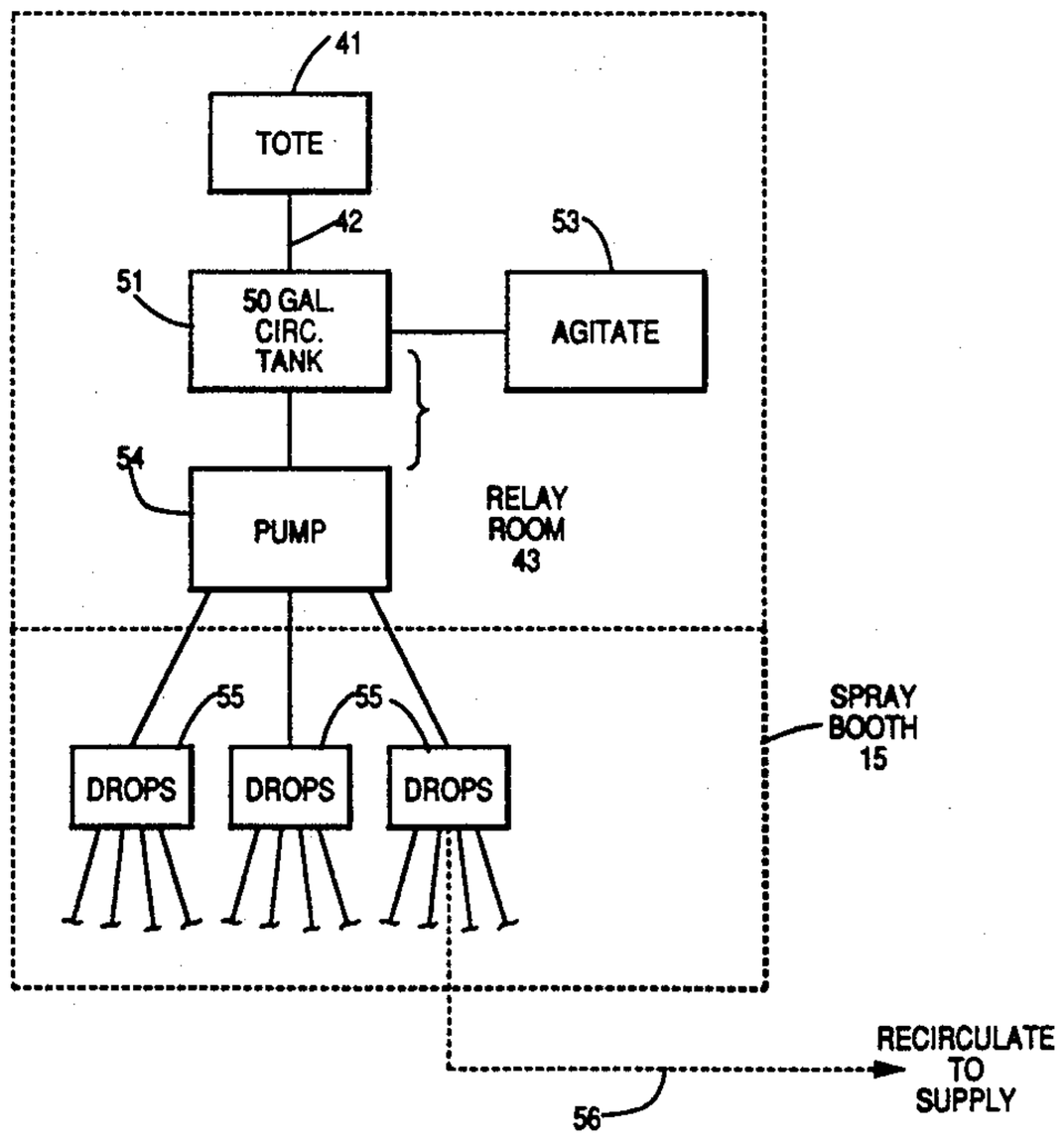
Primary Examiner—W. Gary Jones
Assistant Examiner—Charles K. Friedman
Attorney, Agent, or Firm—Ronald P. Kananen

[57] **ABSTRACT**

An apparatus for recirculating a waterbased paint in a vehicle painting assembly line includes paint totes located substantially adjacent a circulating tank near the point of application of the paint, thus reducing line length and the cost of replacing the paint in the line. This feature is enabled because waterbased paints, unlike solvent-based paints, are not subject to the same volume location restrictions. By maintaining a supply of paint to a low volume tank within narrow limits, a high volume application requirement can be met. A single line recirculating system is also disclosed for use with either type of paint. A number of features of a working paint system are also disclosed, including orbital welding of the stainless steel tubing, passivation of the line, use of DI water for passivation and flushing of the system, low point drains for the system, limited surge, and the use of smooth bore components and transitions to avoid paint sedimentation and buildup.

10 Claims, 13 Drawing Sheets





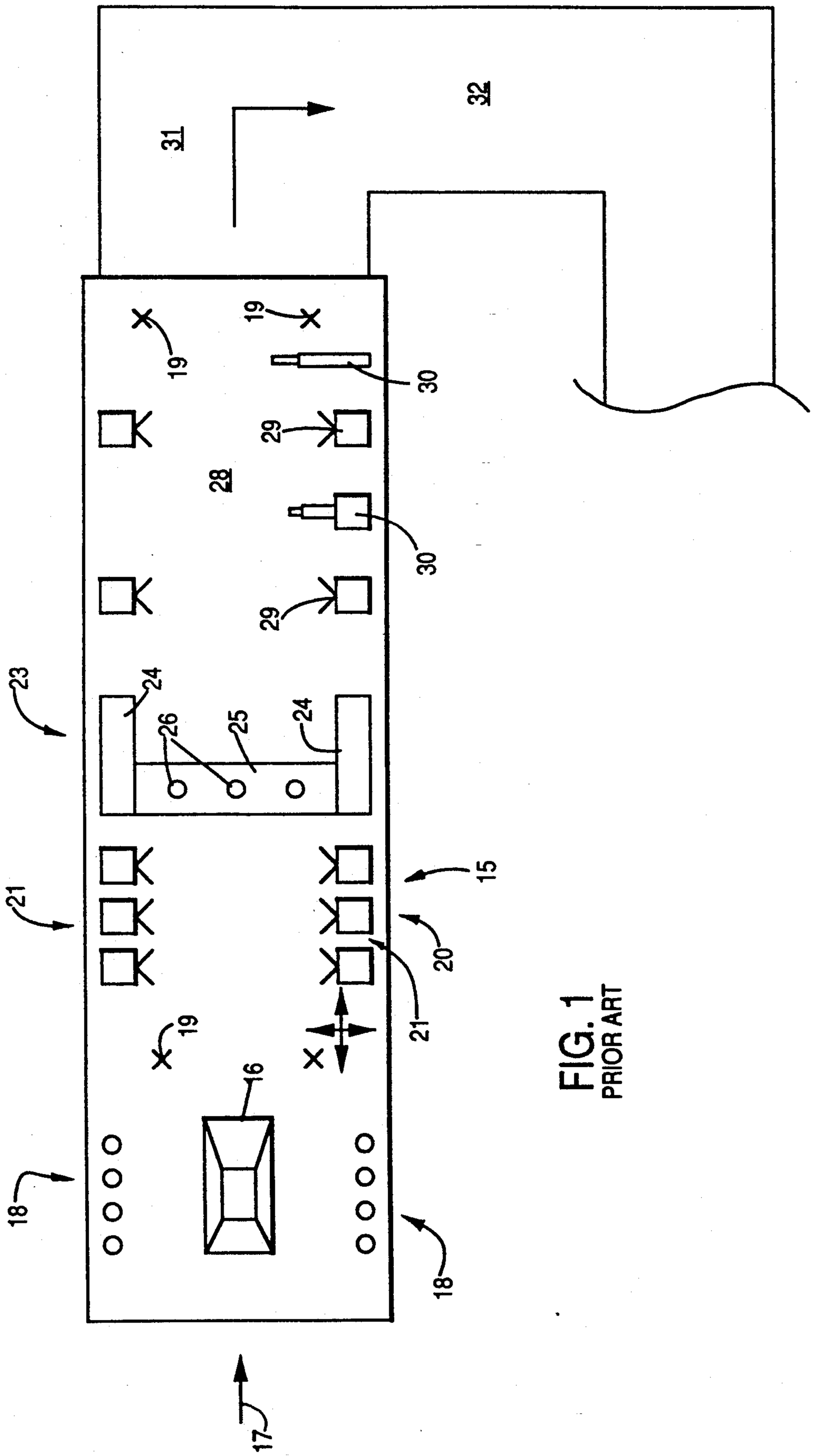


FIG. 1
PRIOR ART

FIG. 2
PRIOR ART

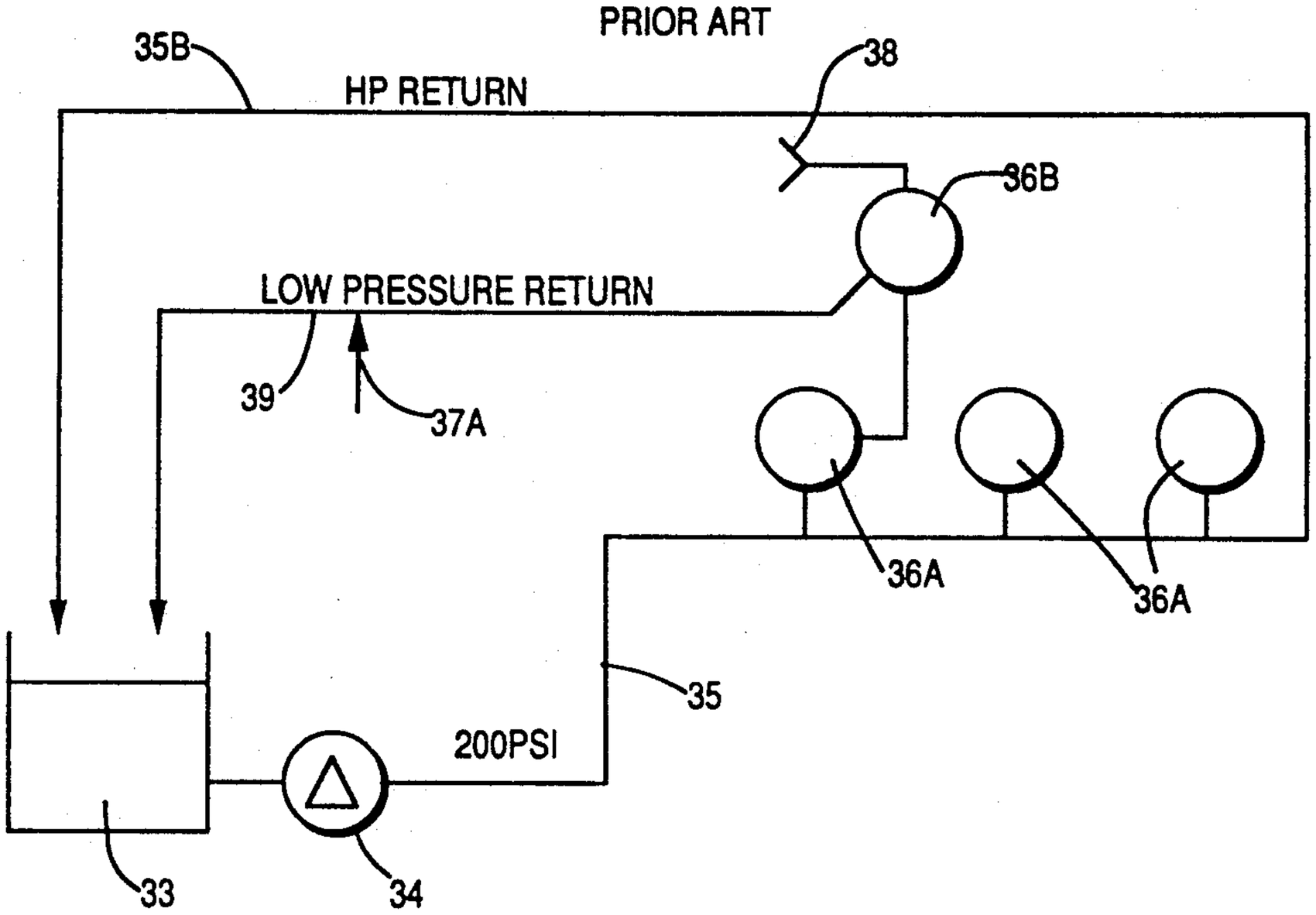


FIG. 3
PRIOR ART

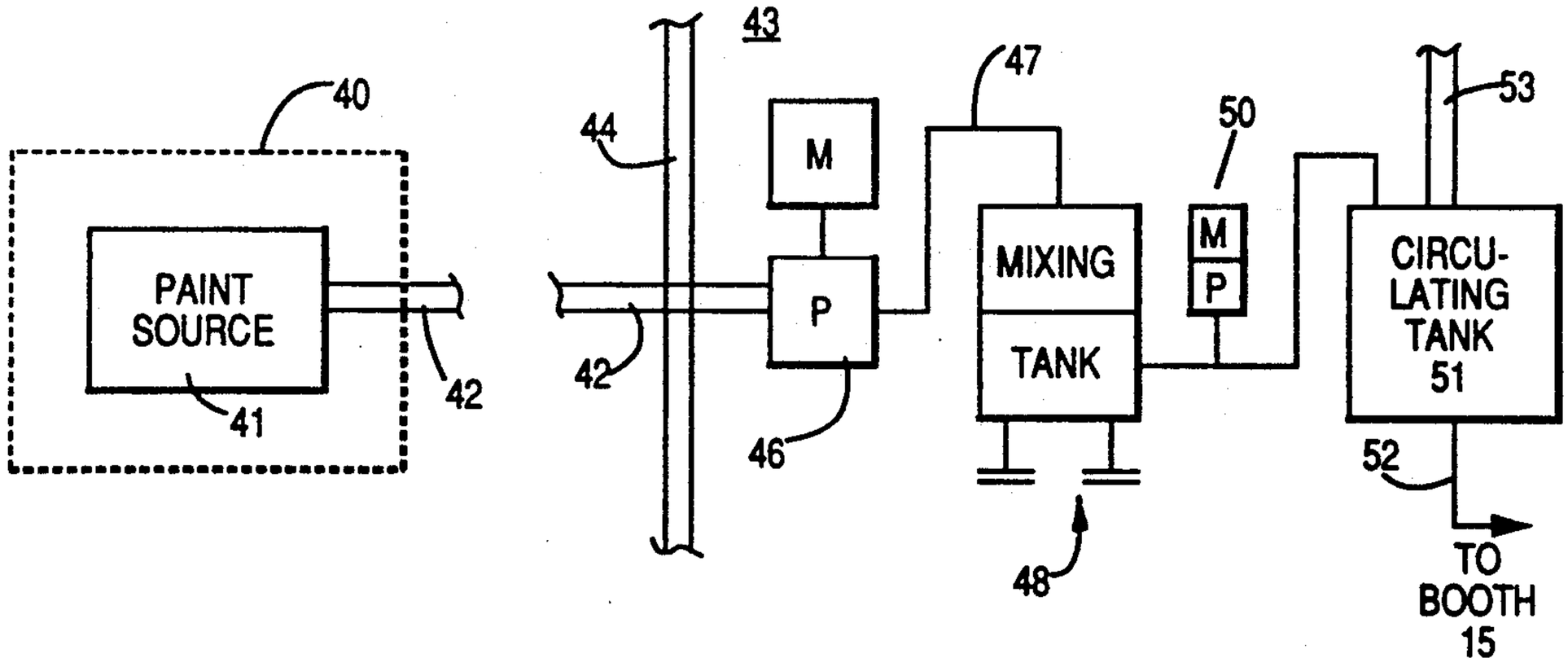


FIG. 4

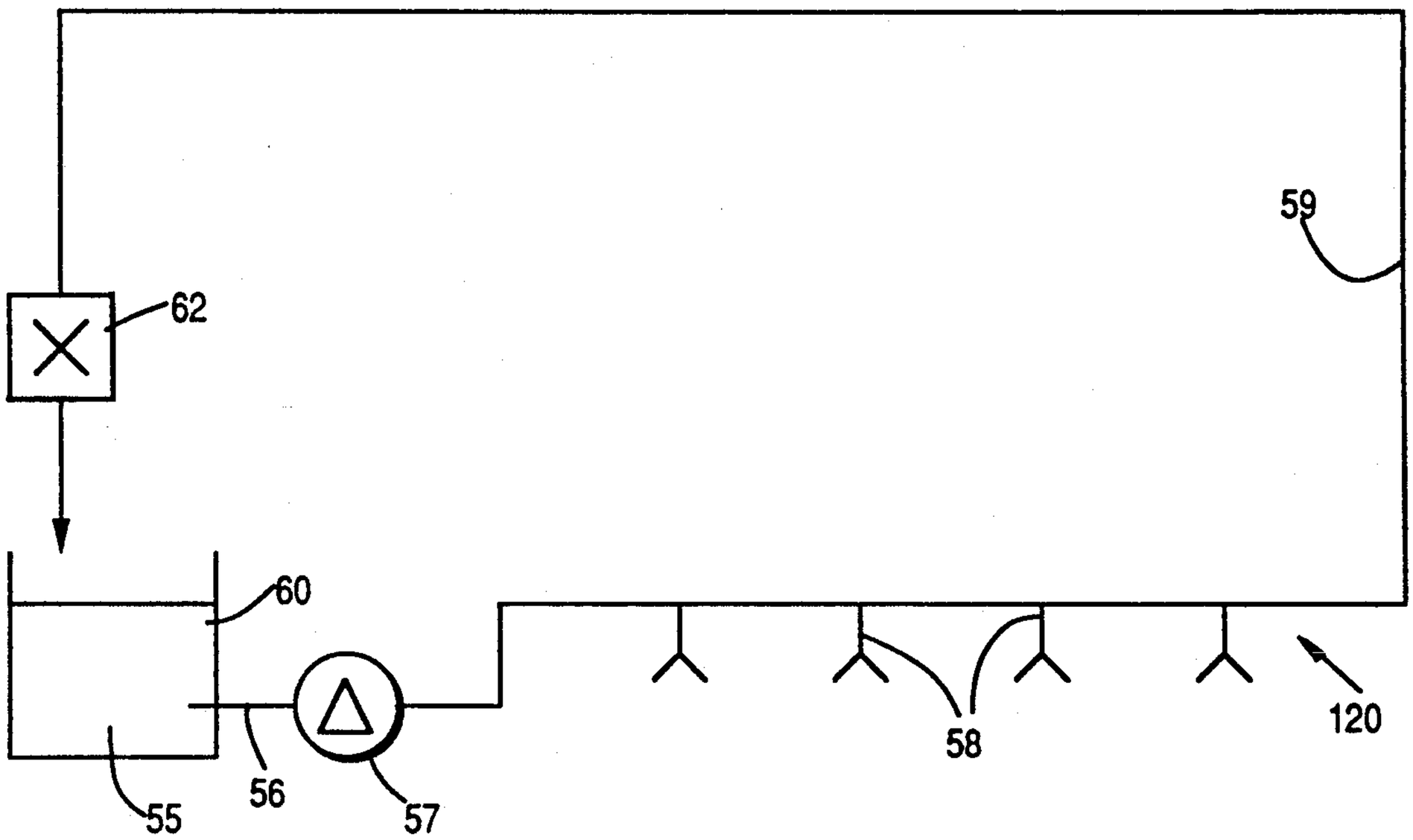

59
62
60
55
56
57
58
120

FIG. 5

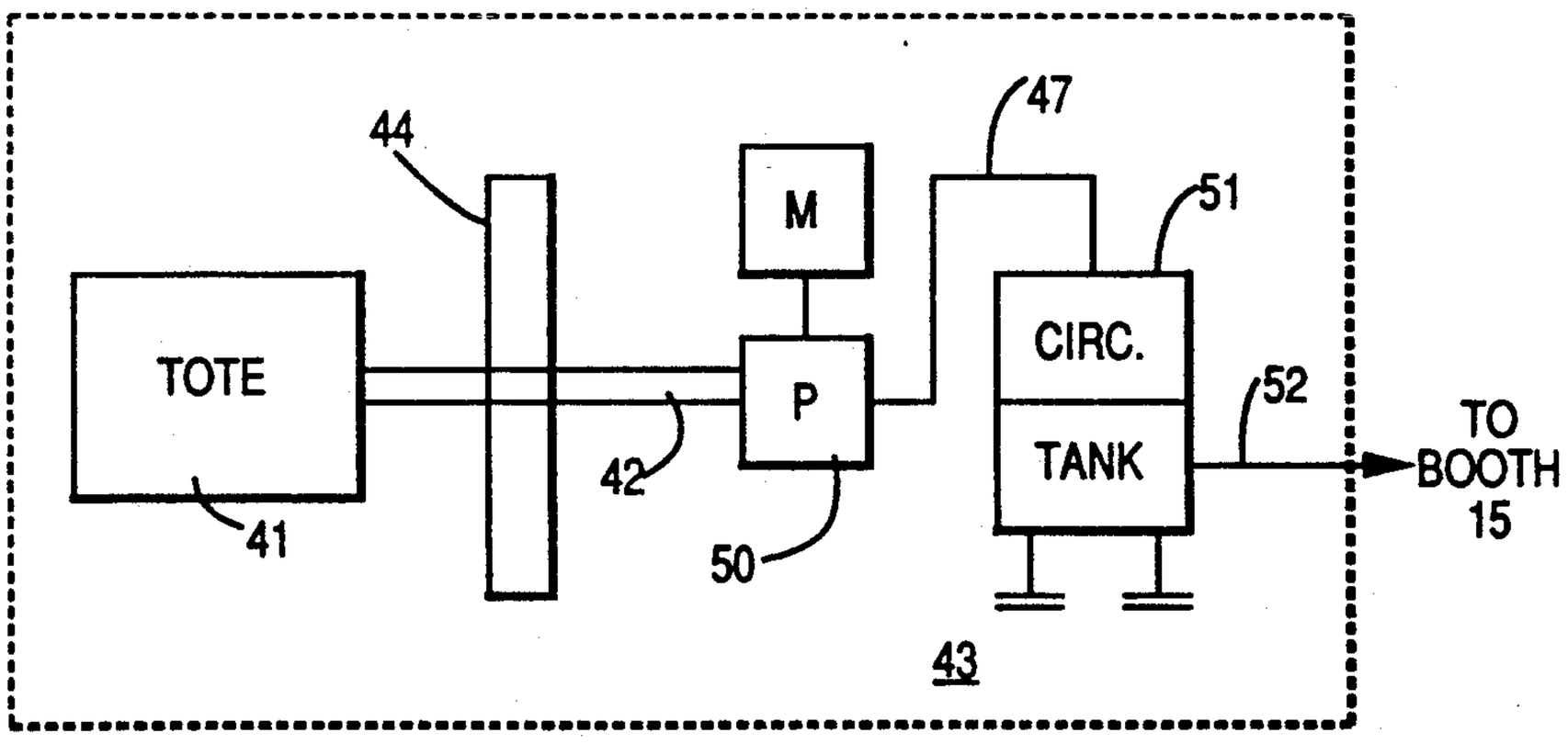
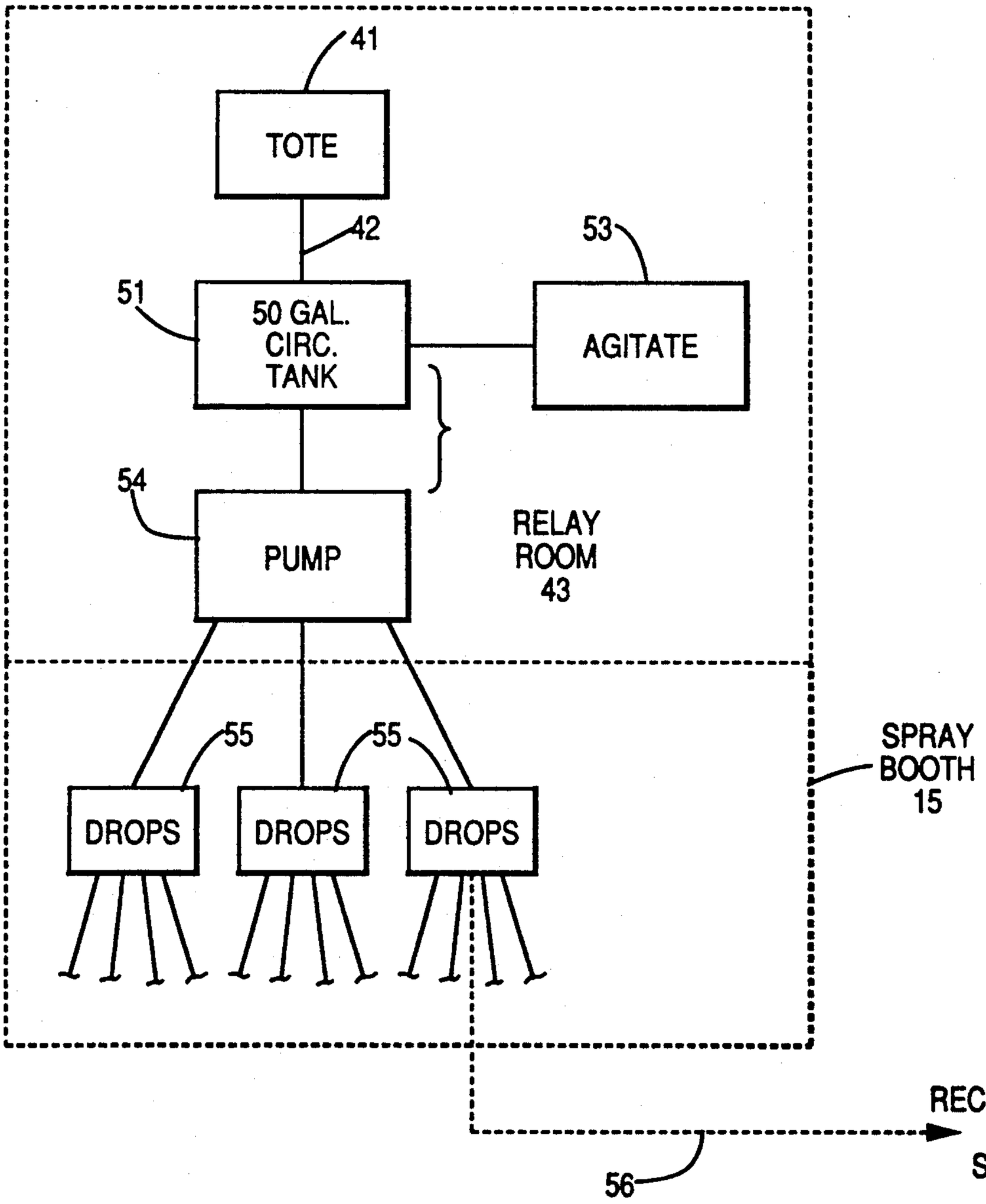

44
47
M
51
TOTE
P
CIRC.
TANK
52
TO BOOTH 15
42
50
41
43

FIG. 6


41
TOTE
42
53
51
50 GAL.
CIRC.
TANK
AGITATE
54
PUMP
RELAY
ROOM
43
55
55
SPRAY
BOOTH
15
DROPS
DROPS
DROPS
RECIRCULATE
TO
SUPPLY
56

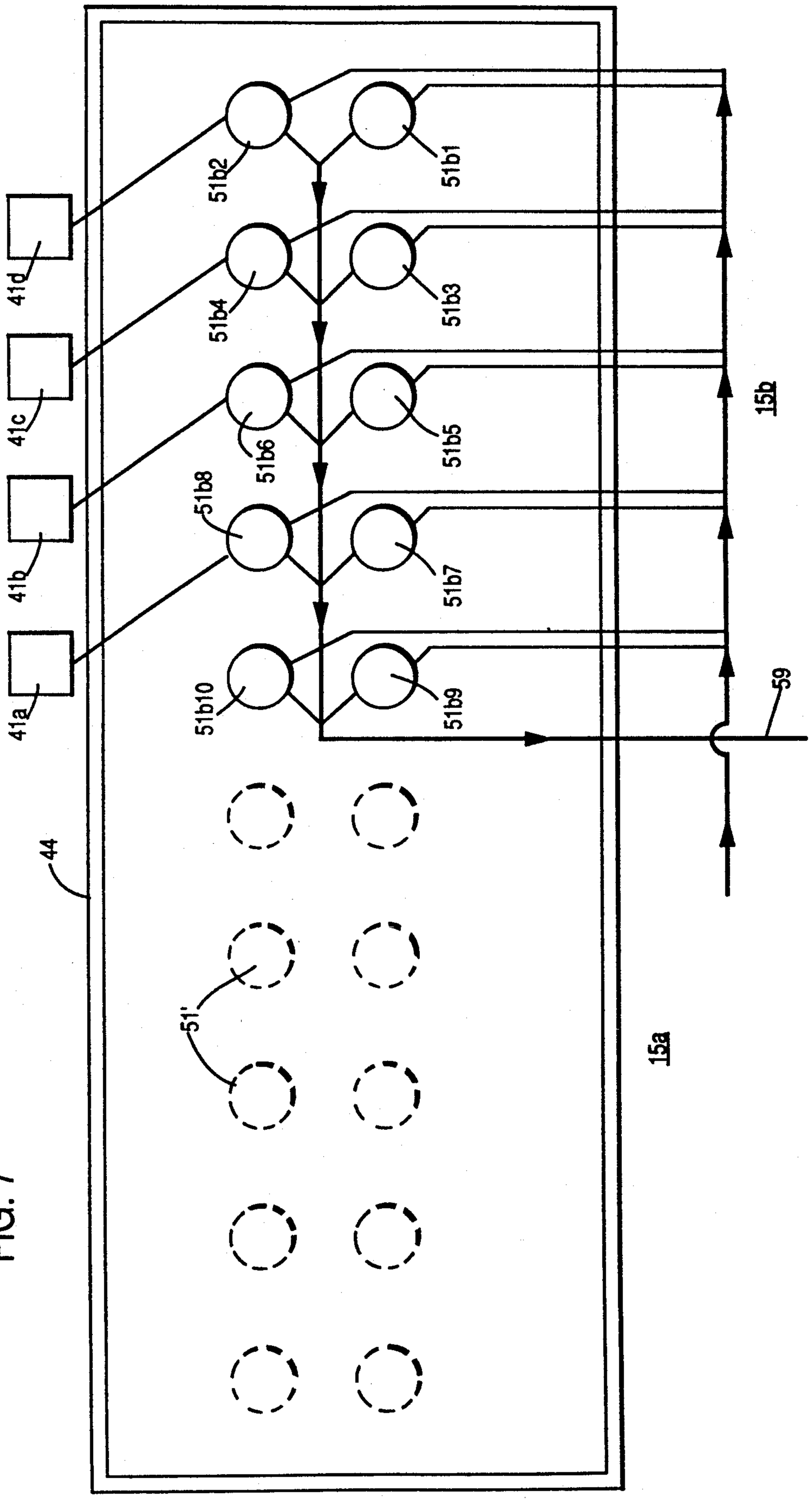

41d
41c
41b
41a
44
51b2
51b1
51b4
51b3
51b6
51b5
51b8
51b7
51b10
51b9
51'
15b
59
15a

FIG. 7

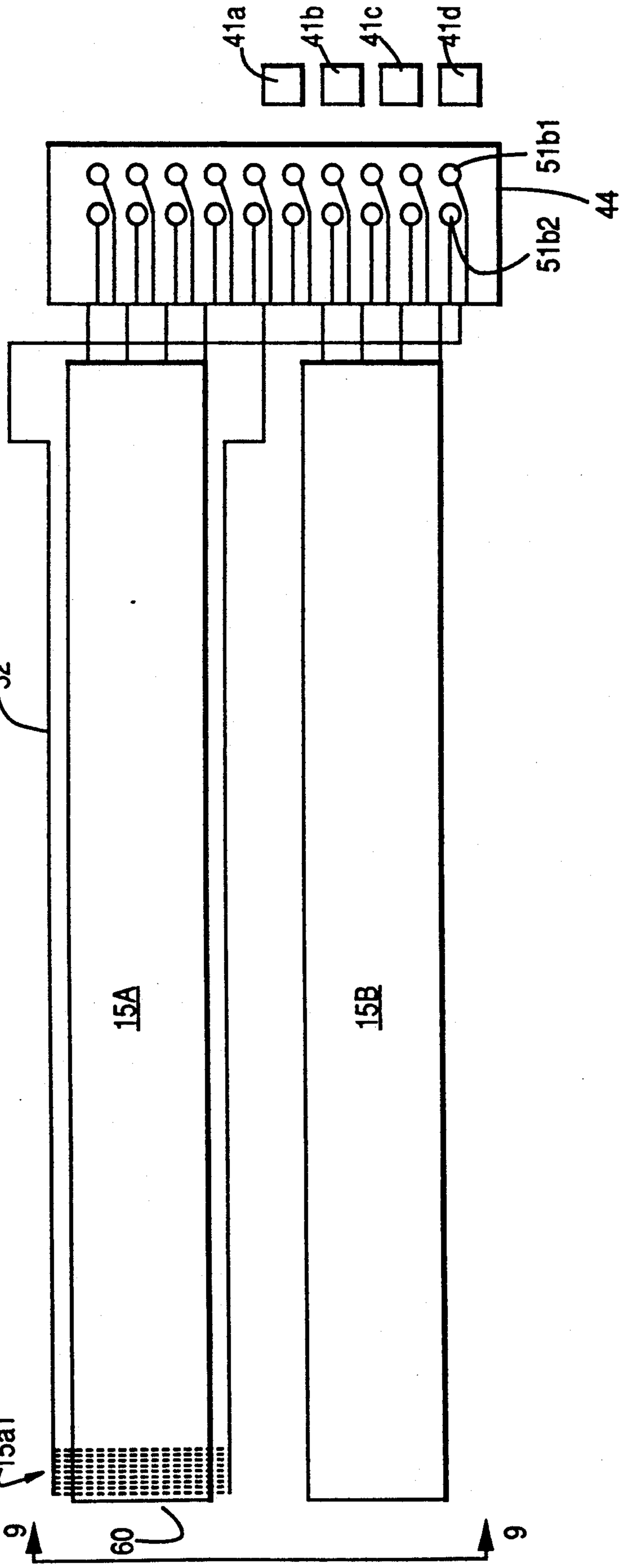


FIG. 8

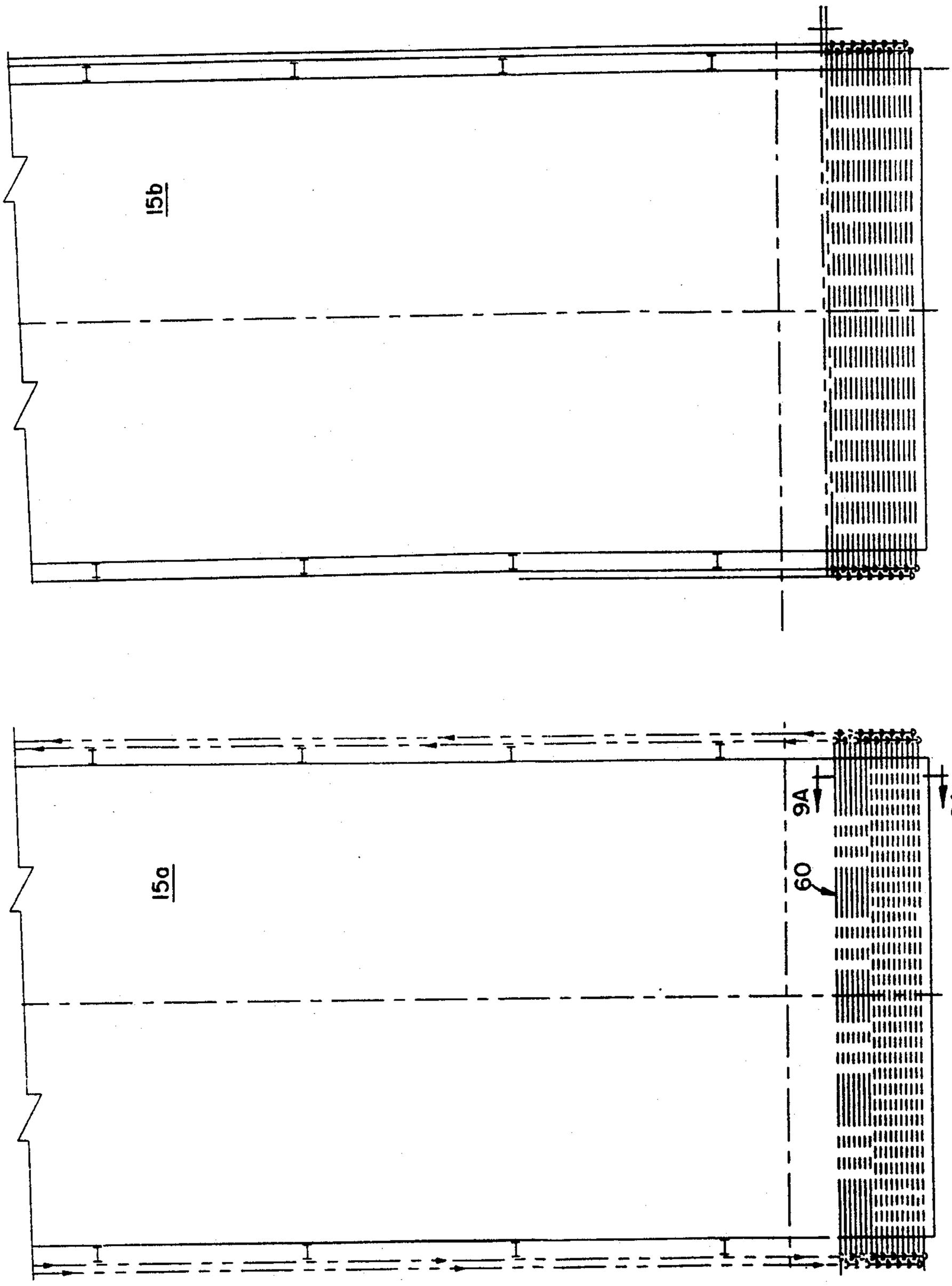
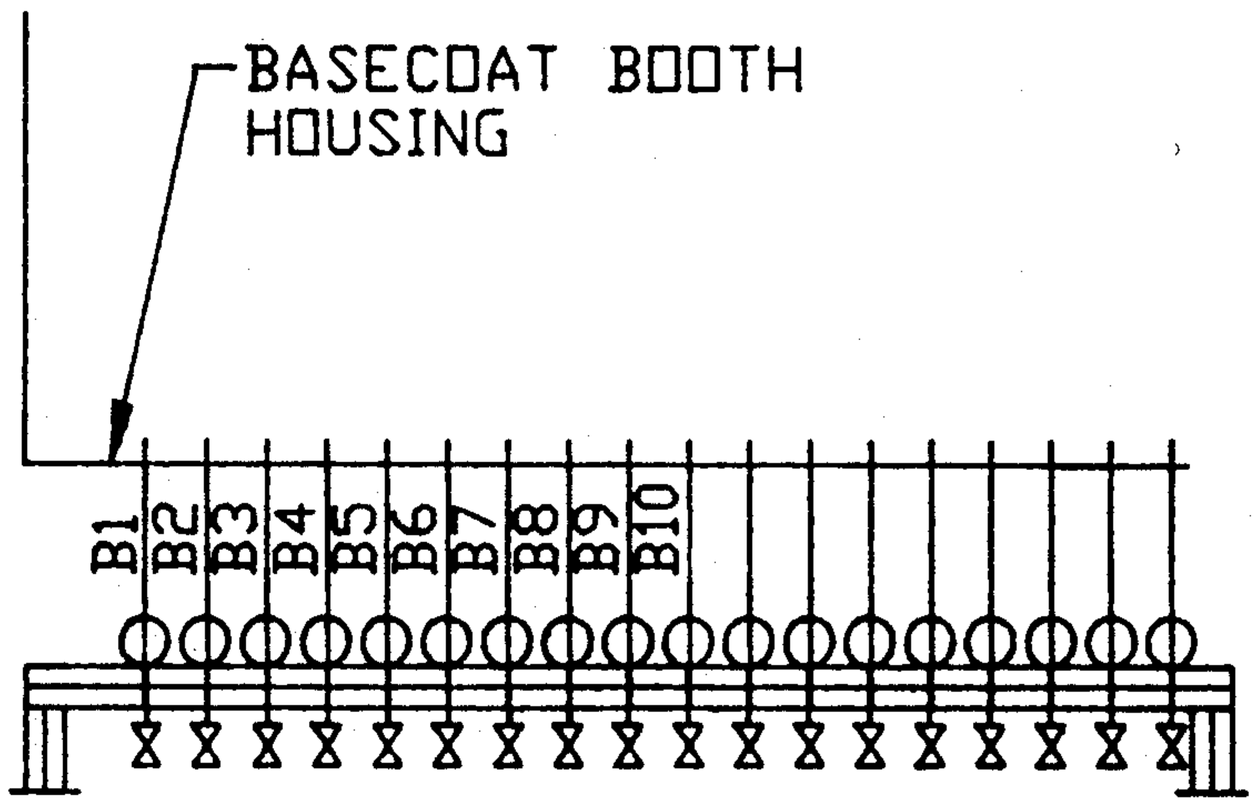


FIG. 6

FIG. 9A



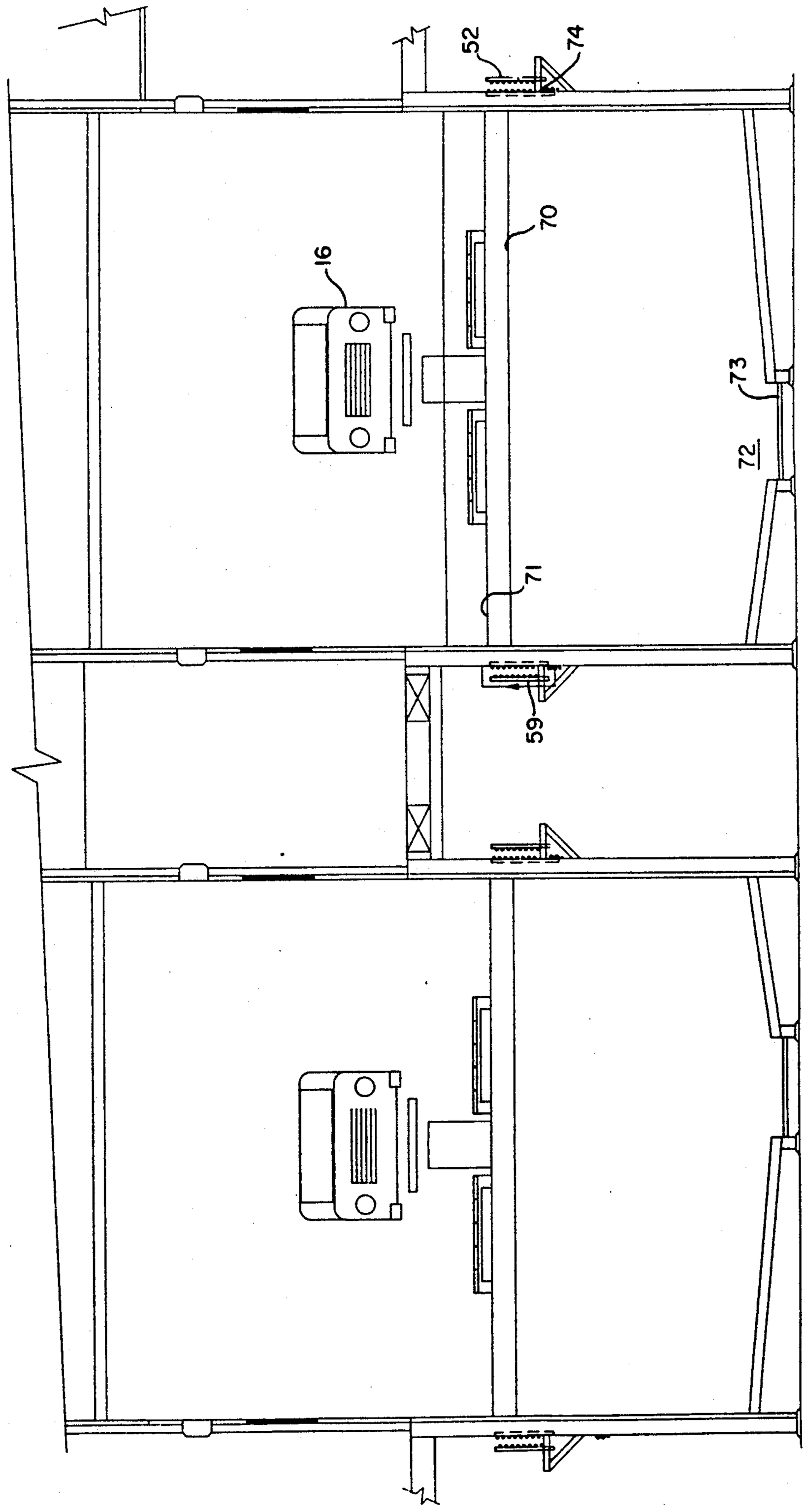


FIG. 10

FIG. 11(1)

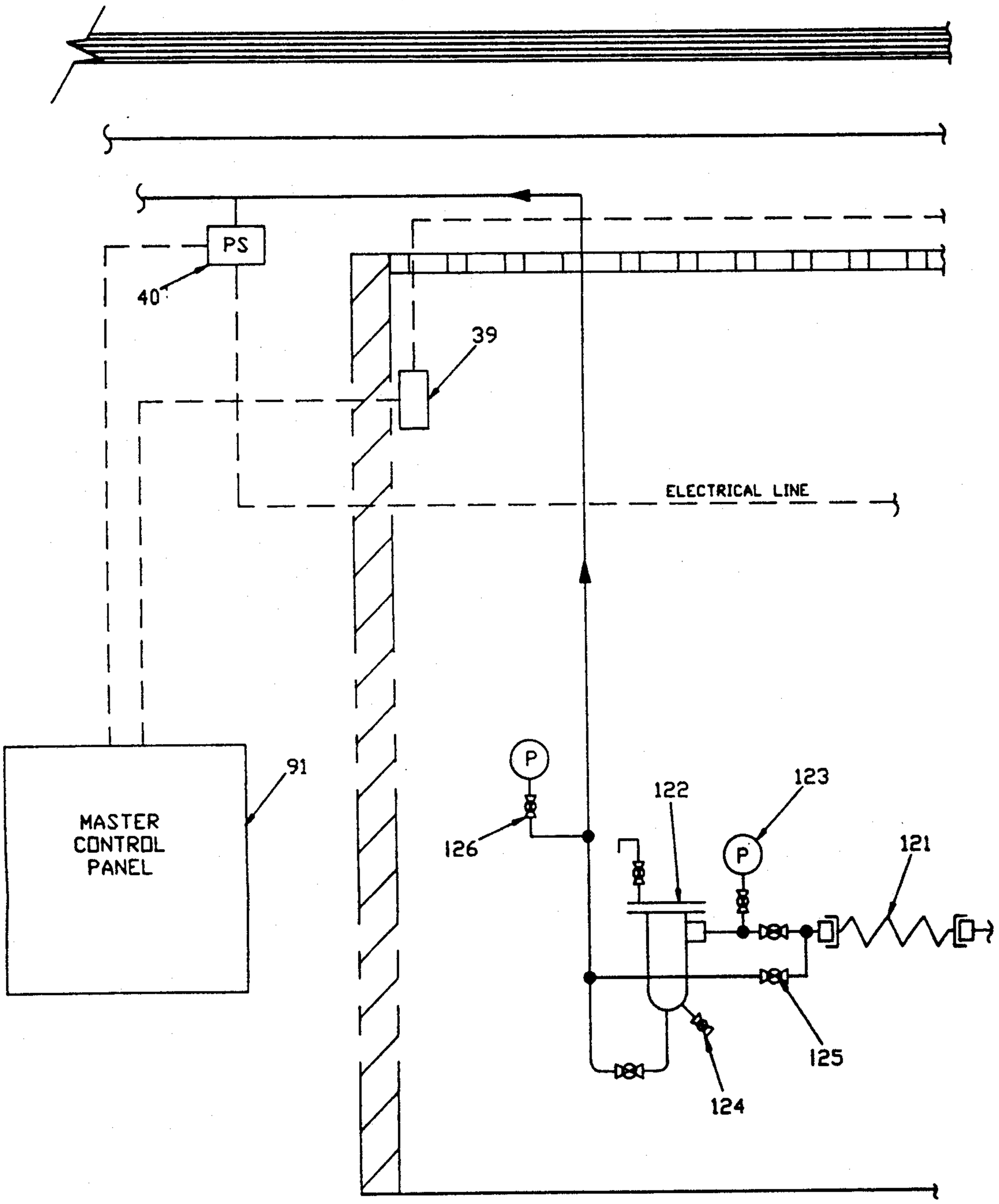

PS
40
39
ELECTRICAL LINE
MASTER CONTROL PANEL
91
P
126
122
123
P
121
125
124

FIG. 11(2)

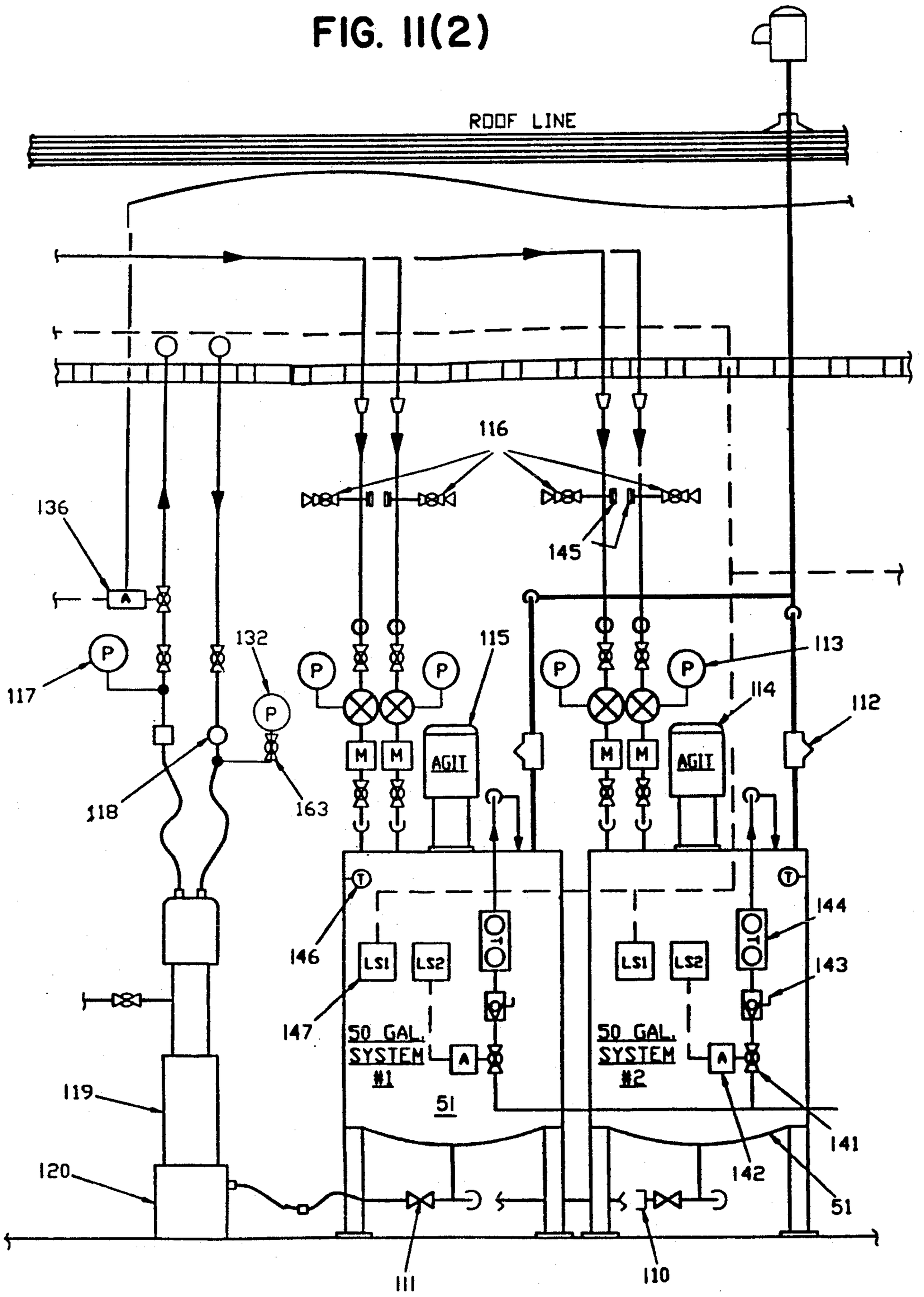

ROOF LINE
116
136
145
132
115
113
117
114
112
118
163
AGII
AGII
146
144
LS1
LS2
LS1
LS2
147
143
50 GAL. SYSTEM #1
50 GAL. SYSTEM #2
51
119
141
120
142
51
111
110

FIG. 11(3)

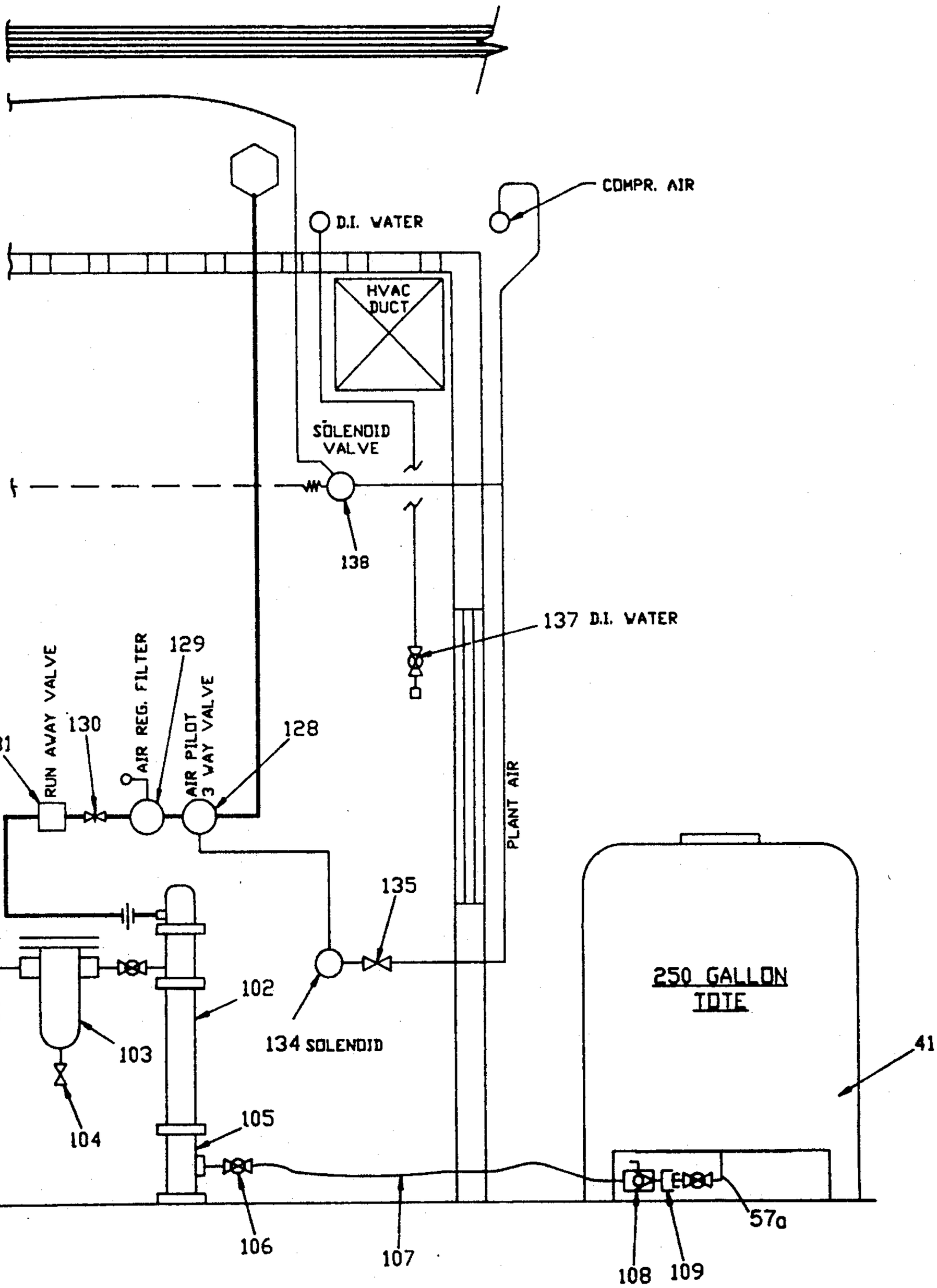
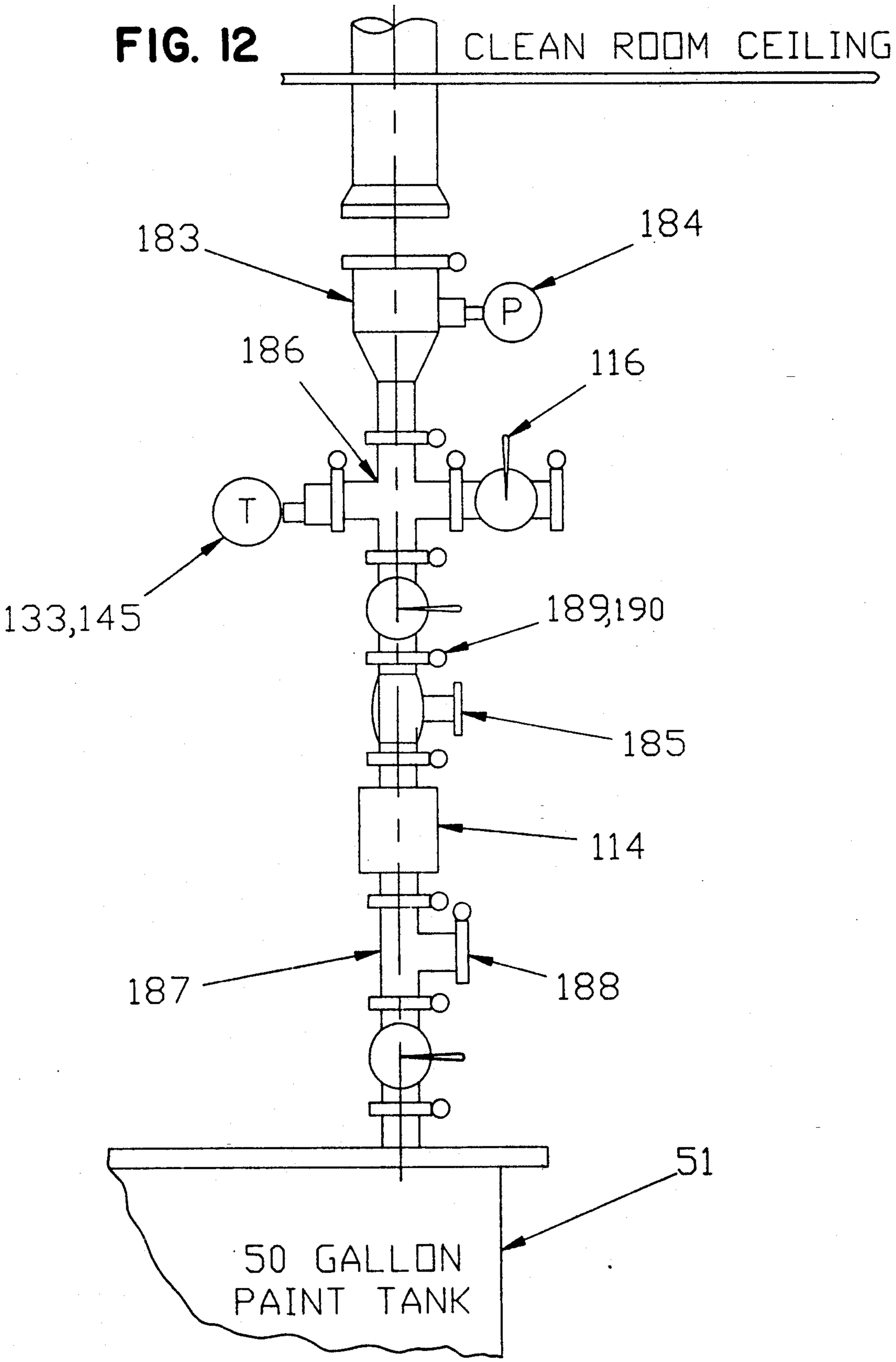

COMPR. AIR
D.I. WATER
HVAC DUCT
SOLENOID VALVE
138
137 D.I. WATER
PLANT AIR
RUN AWAY VALVE
AIR REG. FILTER
AIR PILOT 3 WAY VALVE
131
130
129
128
135
102
103
104
105
134 SOLENOID
106
107
108
109
57a
250 GALLON TOTE
41

FIG. 12


CLEAN ROOM CEILING
183
184
P
186
116
T
133,145
189,190
185
114
187
188
51
50 GALLON
PAINT TANK

CONTROLLED APPARATUS FOR PAINTING VEHICLES

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U.S. application Ser. No. 07/575,672, filed Aug. 31, 1990; now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for applying waterbased paint to a vehicle such as an automobile. More particularly, this invention relates to a paint application and circulation system for applying waterbased paint to a vehicle wherein the paint supply is near or adjacent the point of application. Still more particularly, this invention relates to a low volume content paint supply system employing methods and apparatus for supplying a high volume paint application without resulting in production downtime. Still more particularly, this invention relates to a number of features in such a system for quality control purposes and operator convenience.

The paint finish on a new vehicle is often regarded as the single most noticeable visual feature of the vehicle. When the finish is smooth, even, and attractive, owners are influenced as to the quality of the vehicle, while when contamination, paint unevenness, and other defects are present, the owner is more likely to complain to the vehicle dealer, and attribute a lack of quality to the vehicle itself. Accordingly, vehicle manufacturers and paint suppliers have expended vast amounts of money, effort, and ingenuity to produce quality paints and high quality yet efficient methods of applying those paints to the surface of the vehicle.

It is well known that automotive vehicle production is automated to a significant extent. Indeed, paint is applied to the vehicle while traveling an assembly line by positioning paint booths through which the vehicles travel to receive various coatings of paint. Such techniques are highly developed and include the use of robots to apply the surface paint to the vehicle and to paint door jambs and the like. In the past paint have used structures housing solvent-based paints which must have special explosion proof features such as grounded electrical connections and pressure releasing walls which respond to an explosion, and be located away from the factory. Such requirements of explosion proof systems for high volume storage of either waterbased or solvent-based paint are necessary for safety, but are costly when handling high volumes of either waterbased or solvent-based paints. The capital expense for such structures and long piping lines, with the accompanying pumping cost, is high. Moreover, the amount of paint in the lines which is effectively inventoried is high. For example, a line of 3000' for example, could contain more than 500 gallons of paint which is lost during color changeover, or if there is a change in the paint. In addition, prior paint circulation systems utilized large storage tanks wherein the entire content might be lost or its quality affected during changeover.

When the paint supply is located at such a distance from the point of application, significant pumping energy is required for the viscous paint. The friction generated by pumping for such long distances, and the fact that the piping may be required to pass through hotter areas of a factory, en route from the structure housing

the paint to the paint booth locations in the factory, tend to increase the temperature of the paint, affecting its viscosity. Therefore, heat exchangers or other temperature control devices are usually needed to maintain the paint temperature stability in such a paint system.

Solvent-based paints have the potential for drawing environmental attention to the solvent emissions during utilization. Primer coats and clear coats have a high application efficiency when an electrical potential is used, so that solvent emissions can be reduced. However, unfortunately, color coats are adversely affected by the sole use of an electrostatic application, so that their application efficiency is low and their solvent emissions are higher.

Thus, it is desired to utilize waterbased paints to address environmental concerns resulting from the use of solvent-based paints, while maintaining the quality of the finish on the vehicle.

Moreover, it is a problem in such paint circulating systems to reduce the capital expense for preparing painting systems, and to reduce the amount of paint in the painting lines which is lost during paint changeover, or if there is a difficulty with the paint. In addition, it is a general overall aim in developing and implementing a paint recirculating system to provide for ease of maintenance and replacement. These and other objectives are met by this invention.

Thus, it is an overall general objective of this invention to provide a paint recirculating system wherein a waterbased paint source and the paint system is located adjacent to or near to the point of application in lieu of a typical paint supply source located a great distance from the application point.

It is an objective of this invention to provide a waterbased paint system which uses handling procedures and monitoring methods to reduce the paint volume contents of a local relay room for the paint system to provide a safe environment.

It is another overall objective of this invention to provide a low volume waterbased paint supply source for a high volume usage spray painting application which uses methods and apparatus for assuring that the paint supply is not interrupted.

It is another overall objective of this invention to provide a waterbased paint recirculating system which uses a single line for supply to the waterbased paint drops and return to the circulating tank.

It is another objective of this invention to shorten the piping run from the paint source and the circulating tank to the point of application for a waterbased paint, thereby reducing the amount of paint inventoried in the line and thus reducing the cost of replacement when necessary.

It is another objective of this invention to provide a local booth side system to achieve a major cost reduction of a high purity stainless steel system.

It is still another feature of this invention to provide a piping system which avoids locations which tend to induce paint buildup or sedimentation by using, for example, stainless steel piping which is orbitally welded and then passivated.

These and other objectives of this invention will become apparent from a detailed written description of the invention which follows taken in conjunction with the accompanying drawings.

BRIEF SUMMARY OF THE INVENTION

Directed to achieving the foregoing objectives and addressing the problems with prior art paint recirculating systems, the apparatus according to the invention features the use of a total paint supply system including a tote and a recirculation tank which are at or nearer to a paint spray booth or other point of application than in prior art systems, including solvent-based systems. The apparatus according to the invention includes a source of waterbased paint, such as a tote and a circulation tank, located adjacent to or nearer to the application points than permitted with typical paints; a circulating tank for receiving paint from the tote; means for delivering paint to a predetermined number of drops in a painting booth for painting an automotive vehicle; and means for returning paint to said recirculating tank. The circulation tank includes agitation mean for stirring the paint in the tank, and a level sensing device for maintaining the level of paint in the circulation tank within predetermined narrow limits. This feature permits the use of a low volume supply for a high volume paint requirement and is a significant feature of the invention. The apparatus includes monitoring means for tracking the use of paint through the process to assure that the supply of paint to the high usage volume point of application is not interrupted from the low volume supply.

The invention related to the waterbased paint is characterized in that a non-explosion proof electrical system may be used in a standard relay room housing, not requiring explosion-proof characteristics, for housing the circulating tank and the tote. For such waterbased paints, the invention is further characterized by the absence of a need for temperature control since the paint source is so near to the paint booth wherein the supply and return lines are relatively short, and do not pass through hot or cold areas of the painting system in the factory. Other advantages of the invention include low point drains in the system to facilitate drainage and testing; a short piping loop for clean-out; sanitary fittings; smooth bends and transitions in the piping; orbital welding for the stainless steel fittings; a limited surge of pressure in the system; and rapid changeover to new material.

The method according to the invention includes a step of providing a paint supply system including a tote having a water-based paint and a circulating tank in a relay room nearer to the point of application than the case for a solvent based paint or waterbased paint; providing said waterbased paint to a circulating tank in the relay room; transferring said paint to drops in a paint booth by way of a supply line; and returning unused paint to said circulating tank through a return line.

Another aspect of the invention includes a plurality of totes; a plurality of circulating tanks located in a relay room adjacent said totes for receiving paint from said totes; a paint booth having a plurality of paint drops positioned relative to the passage of an automobile body therethrough to paint said body; a plurality of pipes respectively connected to said circulating tanks and traversing a side of said booth at a location below the level of said vehicle passing through said booth, said supply pipes passing beneath an end of said booth; and a plurality of return lines.

A significant feature of the invention relates to the use of a relay room near the paint booth wherein the relay room need not be explosion proof, arranged so that low volume circulating tanks can supply the high volume requirements of the paint booth without interruption. Means are provided throughout the system for automated monitoring of the process.

These and other features of the invention will be well understood from a detailed description of the invention which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a plan view of a typical and conventional paint booth in a paint shop;

FIG. **2** is a block diagram of a conventional prior art three pipe system used for applying solvent-based paints to vehicles;

FIG. **3** is a typical prior art installation showing a paint supply located significantly far from the point of application;

FIG. **4** is a block diagram of a single pipe system according to the invention for applying waterbased paint to the vehicle in the system according to the invention;

FIG. **5** is a view showing a relocation, according to the invention of the tote and low volume circulation taken adjacent to or near the point of application;

FIG. **6** is a block diagram showing the concepts of the invention for circulating waterbased paints in a painting apparatus and method according to the invention;

FIG. **7** is a partial plan view of a waterbased paint circulating system according to the invention showing totes, circulating tanks, and supply and return lines to and from the paint booth on the assembly line;

FIG. **8** is a plan view of the circulating tanks and supply and return lines to a pair of painting booths, further showing piping crossover at the end of the booths;

FIG. **9** is a rear elevational view of a paint booth showing crossover lines beneath the floor of the booth;

FIG. **9A** is the basecoat booth housing taken from line **9***a*—**9***a* of FIG. **9**.

FIG. **10** is a simplified cross sectional view through a paint booth showing the elevations of the floor, sump, and supply and return lines;

FIG. **11A**, B, and C side elevational views of a preferred embodiment of the equipment provided in the waterbase relay room according to the invention; and

FIG. **12** is a more detailed view of the piping between the return line and the circulating tank.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A typical prior art painting booth is shown in FIG. **1** at the reference number **15** for painting a vehicle **16** while within the booth **15** traveling in the direction of the arrow **17** on the assembly line. A plurality of robots **18** are mounted on opposed sides of the booth **15** for painting a dry body of the vehicle **16**. A portion of the vehicle **16** may be painted manually from the positions noted by the reference numeral **19**, such portion including difficult-to-reach locations. At the next application stage **20**, a plurality of side mounted robots **21** apply paint to the sides of the vehicle **16** in a carefully arranged pattern at a rate designed to completely cover the vehicle to a desired thickness, sometimes depending on the color. Typically, such a pattern resembles a "back and forth" or "to and fro" pattern along the side panels of the vehicle **16**. Such robots may include electrostatic apparatus for charging the paint to a negative

potential to assist its adherence to a vehicle **16** which is grounded or at a positive electrical potential. Such a technique is well known and commercially available from a source such as Behr Engineering in Germany.

At the stage **23**, the horizontal surfaces of the vehicle **15** are painted by an apparatus having side guides **24** along which moves a transverse member **25** having a plurality of paint spray nozzles **26** mounted to face generally downwardly. Typically, the nozzles **26** paint in a back-and-forth or to-and-from pattern to assure a complete even coverage of the horizontal surfaces of the vehicle **15**. A final painting zone **28** having a plurality of painting nozzles **29** and a plurality of horizontally extendible nozzles **30** complete the painting of the vehicle **15** which then passes along the path **31** to a drying zone **32**. For solvent-based paints, the drying zone is controlled to a relatively hot temperature to drive off the solvents which require careful handling to comply with environmental regulations. A significant advantage of painting with waterbased paints according to the invention is their ease of handling with respect to environmentally-sensitive emission matters.

A paint booth **15** such as is shown in FIG. **1** is generally mounted in a factory building such that the level at which painting occurs is somewhat intermediate an upper level and a lower level which receives the emitted, but unapplied paints for disposal. As used in this specification, spray locations at the heads **21**, **16**, **29**, and **30** are generally referred to as "drops" or "paint drops".

FIG. **2** is thus an example of a conventional 3-pipe system used for applying solvent-based paints to vehicles. Thus, a supply tank **33** provides agitated paint to a high pressure pump **34** providing paint at a high pressure of about 200 psi on a high pressure supply line **35** to a plurality of regulators **36A**, each of which is connected to a low pressure recirculating regulator **36B** to reduce the pressure to about 25 psi to a representative drop **38**. The outlet of the low pressure regulators **36B** provides a low pressure return on the line **37A** to the tank **33**. A high pressure supply line **35** continues around all booths to the furthest-most or last required paint drop condition and at that point becomes the high pressure return line **35B** and continues back to the paint tank **33** located in the external paint mix building to keep the paint circulating throughout the piping network. Such 3-pipe systems have served well for their intended purpose, but have sometimes suffered from wide pressure variations on the order of 50 to 100 psi stemming from a difficulty in balancing the relatively-complicated system. A main feature of the invention therefore is to simply the system of FIG. **2** to a single pipe system suitable for use with waterbased paints and for solvent-based paints as well.

FIG. **3** is still another prior art block diagram showing a tote location and pumping station at location **40** housing a plurality of totes **41** at a location significantly remote from the paint spray booth, where mixing tanks **48** and circulation tanks **51** and pumping stations are located for solvent-based paints. Typically, by code, a solvent-based paint system is located some 80 or 90 feet from the main factory facilities in a paint mix building **40** having an explosion-proof environment, such as a class **1**, division **1** environment with explosion-relief walls, grounded components, and an explosion-proof electrical system. Such features are a costly, but necessary adjunct to storage and delivery systems for solvent-based and waterbased paints necessitating a significant capital expenditure. The paint application booths are a significant distance from the building due to process layout.

In addition, such a distance requires additional pumping capabilities to move a viscous paint through the required separation distance. In addition, the volume of paint stored in the lines is significant for such a paint loop having an overall length of 3000 or 4000 feet of 2" line holding some 500 to 600 gallons of paint having an average cost of perhaps $40 to $50/gallon. When a paint color is changed, or at model changeover, or when a defective paint is discovered, a loss of that amount of paint is significant but is necessitated by the requirements for handling paint products.

At the pumping station located in its space **40** paint is withdrawn from the base of the mixing tank **48** and pumped by a pump **50** to a circulating tank **51** having its outlet connected to a supply line **52** for providing the spray paint booth locations typically away from housing **40** to a plurality of drops in the paint booth **15**. The return lines **53** provide a return for the paint to the circulating tank **51** located in housing **40** from the paint booth **15**.

The basic premise for the paint circulating system according to the invention is shown in FIG. **4** where a circulating tank **55** has its outlet connected to a conduit **56** and a pump **57** to a plurality of drops **58** located in a paint booth **15** in the system. A single return line **59** returns paint to the circulating tank **55**. A feature of the invention is that the recirculating tank **55** has a limited capacity and the paint level is maintained within a narrow band so that the interior walls on the recirculating tank **55** do not dry before a replacement supply of paint is provided to return the tank to an optimum level **60**. Typically, the control level in the tank **55** is maintained within a 2" to 3" band. This notion permits a low volume source to service a high volume usage in a paint booth.

The system of FIG. **4** has an advantage of providing a high pressure return through a back-pressure regulator **62** and no requirement for a low pressure return. Such a system permits a number of capital advantages in reducing the number of lines required compared to the prior art system of FIG. **2** and reducing pressure in the main header without inducing heavy shear points.

As an overall indication of the characteristics of the system according to the invention, it should be noted that a number of features are provided to prevent paint buildup and paint sedimentation in the system. For example, since water-based paints have a high content of DI water, the product is extremely corrosive, and requires high purity stainless steel construction material to prevent system corrosion which can cause paint contamination. Each of the stainless steel pipes is a seamless pipe having its end orbitally welded to the adjacent line to provide a smooth interior passageway. The preferred components are Type 304 and Type 316 stainless steel, 150 grit surface finished products, while products requiring welded fabrication are of the low carbon content or Type 304L and Type 316L steel. Orbital welding techniques for stainless steel to provide such smooth interior passageways are well known in other industries, but have heretofore not been applied to automotive paint recirculating systems. During welding, the piping and weld head are purged with argon gas to prevent weld sugaring and use of L-grade stainless steel to prevent inter-granular precipitation. Each of the pipes has a smooth bend with a large turning radius to avoid creating a locus for sedimentation of the paint or

paint buildup. Clearly, paint buildup or sedimentation is undesirable for if a "glob" of paint reaches a drop and is deposited on a surface of the vehicle, the vehicle would need to be removed from the assembly line, sanded, and returned for repainting. Thus, the system is engineered to keep the paint continuously fluid within the system.

Another feature of the invention resides in the passivation of the lines prior to initial usage. Orbital welding of the stainless steel pipes exposes some carbon from the metal at the welded joint area. A suitable cleaner, such as an alkaline cleaner and DI water solution heated to 140 degrees F., is passed through the piping, followed by a solution of an acid, such nitric acid and hot (140 degrees F.) deionized (DI) water in a proper ratio, such as 15:85. The solution is circulated through the piping for about 1 hour and the system is then flushed with DI water. Such a treatment makes passive any exposed carbons which could cause rust or corrosion and inhibits rusting of the metal. Such passivation techniques for stainless steel are known in the food industry, but have not heretofore been applied to automotive paint recirculation systems.

Another feature of the system is its utilization of low point drains under the booth **15** so that the system can be flushed with DI water for cleaning, such as when changing colors or when there has been an incident of sedimentation. With both the supply lines and the return lines below the grade of the paint booth **15**, such cleaning is facilitated.

FIG. **5** contrasts the system of the invention with the prior art system shown in FIG. **3** where like reference numerals are used to indicate like parts. It should be noted that a significant feature of the invention is that the tote **41** and the circulating tank are within the relay room **43**, that the mixing tank is unnecessary, and that the relay room contains all of the total pumping station. Thus, paint from the tote is provided directly to the circulating tank **51** for transmission to the booth **15**. It should also be noted that the room **40** (FIG. **3**) for the totes **41**, the pumps **50**, the circulation tanks and transport piping member **52** is eliminated since the paints are waterbased and designed within the regulatory restrictions regarding the paints used. Recognition of that property and its utilization in developing the waterbased system of FIG. **5** is an important discovery on which the invention is bottomed.

Among the advantages of the system of FIG. **5** according to the invention is that the capital expenditures for piping are significantly reduced because the tote **41**, pumps and tanks all in the relay room **43** are located adjacent or near the paint booth **15**. Moreover, the length of the paint loop around the booth can be reduced, and transport piping is non-existent due to absence of the externally-located paint building to thus reduce the inventory of paint in the piping network. As a practical example, it was possible to reduce the loop length to about 520'. This reduction is significant when the paint in the loop must be discarded for color change, for example, or for model changeover; there, the paint in the system is wasted at an average cost on the order of $50 per gallon. Thus, significant savings are realized when it is remembered that a number of colors are involved. For the system contemplated, ten basic colors are utilized for a single paint booth; however, the system is arranged for multiple booths and planned for an additional 10 colors.

A tote **41** is the conventional manner of providing paint from the manufacturer to the ultimate user. The paint tote selected for this design is on the order specific for this design to meet codes of 275 gallons, while a circulating tank **51** is on the order of 50 gallons. These volumes permitted the use of a specific amount of paint within the factory at the point of application, while meeting codes. The arrangement is metered so that an alarm is sounded to warn of an impending need for a new tote; thus "just-in-time" inventory techniques can be applied using the system of the invention.

Thus, the system provides paint safely and in compliance with applicable local codes and state and federal laws to a high volume paint spray application from a local paint delivery system, wherein the amount of paint contained at the local delivery system must be minimized to specific and stated amounts, even in the case of waterbased paints. Where local codes vary and have an effect on the amounts of contained materials allowed, the system can conform to those differences by altering tank sizes, paint level (by adjusting the level sensor probes) and by altering paint tote size and by altering the number of totes allowed to be on line at any given time. For example, if the local or state code restricts the amount of paint allowed in a relay room to 500 gallons, and 10 colors are required, 10 recirculating tanks of 40 gallons each will be within the code requirements for a total of 400 contained gallons. If the number of colors increases to 20, the level sensors can be altered so that 20 tanks each have 25 gallons for a total containment of 500 gallons, within the code restrictions. By limiting contained values to less than exempt amounts, the relay room is thus not rated as a hazardous environment and it does not require explosion proof electrical components for control devices, electric motors on agitators, pumps, room lighting, and so forth, and the building itself is not required to be explosion proof. These features result in significant cost savings.

FIG. **6** shows a flow diagram for the steps according to the invention. The method of recirculating a waterbased paint for application to a vehicle, such as an automobile, in a paint zone in an assembly process, includes a step of providing a waterbased paint, such as in a tote **41**. The method further includes the step of providing the paint from the tote **41** to a circulating tank **51** located in a relay room **43** beneath the mezzanine adjacent to the paint booth **15**, while continuously agitating the paint, as shown in the step **53**. The paint from the circulating tank **51** is provided by a pump **54** located in the relay room **43** to a plurality of drops **55** located in the spray booth **15**. The method concludes with the step of recirculating the paint to the supply tank **51** through the return lines **56**

FIG. **7** shows a plan view of the paint circulating system according to the invention in a preferred piping embodiment, representatively showing a situation where a paint booth **15***a* is in operation while an adjacent paint booth **15***b* is available for expansion of the system. Thus, a plurality of totes **41***a* to **41***d* are provided outside the wall **44** for supplying paint to a plurality of circulating tanks **51***b***1** to **51***b***10**. The circulating tanks are respectively connected to a plurality of supply lines **52***b***1** to enable that sampling line becomes return **52***b***10**, while a like plurality of return lines **59** respectively return paint to the tanks **51**. A plurality of further tie in points **51'** are available for expansion to serve the second paint booth **15***b*.

FIG. **8** shows a plan view of the paint booths **15***a* and **15***b* relative to the totes **41***a* to **41***d*, the wall **44**, the circulating tanks **51***b***1** to **51***b***10** and the tanks **51'** avail-

able for expansion. The supply pipes cross under the booth **15***a* at its end **15***a* remote from the tanks **51** as shown generally by the reference numeral **60**. Otherwise, the reference numerals used in connection with FIG. **8** are like those used in connection with FIGS. **5** and **7**.

FIG. **9** is an end view of the paint booths **15***a* and **15***b* taken from line **9—9** in FIG. **8** showing the crossover pipes **60** beneath the painting level of the booths **15**. Otherwise, like reference numerals are used as in connection with FIGS. **7** and **8**.

FIG. **10** is a side cross sectional view of a paint booth **15** showing its elevation. The mezzanine level is shown at the reference numeral **70** above which a vehicle **16** passes for painting as previously described. Gratings **71** are provided through which unused paint falls to a lower area **72** for runoff with water to a drain **73** where the waterbased paint and water are treated ecologically and the unused paint recovered. The supply lines **52** are shown in cross section. For flushing and cleaning, DI water is available at the line **74**. The return lines **59** are also seen.

FIG. **11** is a detailed line diagram of the schematic of the pumping station located in the relay room. The tote **41** has its outlet **41***a* connected through a quick disconnect **109** to a check valve **108** connected to a pump suction hose **107** to a pump valve transfer fitting **106**, thus to provide paint to a transfer pump stand **105**. A transfer pump **102** on the transfer stand **105** pumps paint through a paint filter **103** to the inlet of the shown circulating tank **51**. A filter drain valve **104** is provided on the filter for convenience in cleaning and replacing the filter.

The pump **102** is pneumatically operated from an air source **94** providing air through a 3-way air valve **128**, an air regulator and filter **129**, an air isolation valve **130**, and a pump run-away valve **131**, connected in series. A compressed air source **95** is connected to an air isolation valve **135** and to a transfer pump solenoid **134**.

As described above, DI water is used to clean the lines of the system, and to flush piping during changeover. Thus, a source of DI water is provided to a DI water ball valve **137**.

Each of the tanks **51** which are representatively shown is connected to an agitator **115** to maintain motion in the paint in the tanks **51**. The return lines return paint to the tanks **51** through a return line drain **116** and through the piping arrangement shown in FIG. **12**. A ball valve **141** is connected to an air operator **142** in circuit with a level sensor LS2. A level sensor LS1 cooperates with the sensor LS2 to maintain the paint level in the tank **51** within predetermined narrow limits as previously described. The ball valve **141** is connected to a check valve **143** in circuit with a gear meter **144**. A temperature sensor **146** is located on the tank **51** to measure the temperature of the paint in the tank, while a temperature sensor **45** is located in the return line to measure the temperature of the returning paint.

Paint from the outlet of the tanks **51** is provided through a suction line cap **110** through a suction valve **111** to a supply pump **119** located on a pipe stand **120**. The pump **119** is hydraulically operated by hydraulic fluid in the lines **90** passing through the hydraulic fluid regulator **118**. A hydraulic pressure gage **132** in series with a hydraulic pressure gage isolation valve **163** are also provided. A pressure gage **117** is located in the paint return line for monitoring pressure in the pump supply system. A pressure switch **140** is also provided for sensing the pressure in the outlet line to provide a signal to the control panel **91**. An output derived from system overpressure closes valve **138** to shut down in the end result paint pump **119**.

The system is equipped with significant safety and operating controls. When a system aberration is sensed by a signal provided to the master control panel **91**, a signal is sent to the alarm transmitter panel **39** where a beeper signal is sent to advise responsible personnel of the aberration.

The output from the pump **119** is provided through a supply hose **121** through a quick connect fitting to a paint filter **122** having a paint pressure gauge **123** connected in line. A filter drain valve **124** is provided for the valve for operator convenience in cleaning or replacing the filter. The output from the filter **122** is provided as a supply line to a drop in the paint booth **15** as previously described.

The details of the return lines are shown in FIG. **12**. The return line **96** is connected to a reducer **183** which may be used because the system is basically a single pipe system as described in connection with FIG. **4**. There, the system pipes is reduced from 2″ to 1″. The reducer **183** is connected to a pressure gage **184**. The outlet of the reducer is connected to a cross **186** having a temperature gage well **133** connected to a temperature gage **145**. The other side of the cross **186** is connected to a manual return line drain valve **116**. The outlet of the cross **186** is connected through a valve to a clamp **189** with a gasket **190**. A pinch valve **185** is connected to the outlet as described and to a paint flow meter **114** for monitoring return flow. A tee **187** and a cap **188** complete the piping for the return station for the paint return lines.

Thus, as can be understood from the foregoing, the water-based material is delivered to the factory in bulk stainless steel containers, and stored in inventory in an explosion proof building along with the solvent based products for compliance with codes and laws governing combustible product storage remote to the main plant. A paint mix associate, knowing the daily production requirements for the colors to be painted, selects the paint totes which will be required for delivery to the relay room where samples are taken for static viscosity and ph levels. The tote is weighed for entry to an automated material usage tracking sequence on a data processor. The processor subtracts the known weight of an empty paint tote and converts the given data into engineering units of volume in gallons according to a mathematical formula according to paint color.

When the paint tote is transported and connected to the relay room supply line, paint usage tracking and monitoring begins. As previously explained, each tank has an automatic level control via level sensors interacting with automatic activated fluid shut off vales. As shown in FIGS. **11** and **12**, when the level in the circulation tank is lowered, the level sensor **147** provides an input to the processor producing an output to the solenoid valve **134** which in turn pilots the a shut off valve **128** to the open position. This sequence refills the paint recirculation tank to a present level, and the valve **134** is closed.

The gear meter **144** is utilized as a totalizer in this system measuring paint flow through the system, for subtraction from the original supply data. This method permits monitoring of the paint tote volume without any devices in the paint tote itself. When an input is provided to the processor indicating a low level in the

tote, an auto dialer is actuated communicating through the plant phone system to the paint mix operator equipped with a beeper. Thus, the system does not require occupancy to keep system from running out of paint.

For added protection, audible horn and visual beacons are energized if the level sensor **147** ever sees a low level condition implying that the paint tote has emptied and that the tank level has traveled below its normal operating level to a second preset low level position. This paint fill and usage tracking sequence demonstrates the use of a 50 gallon tank with only 25 gallons of paint therein to supply a high volume paint operation.

Thus, the basic features of a waterbased paint recirculating system have been shown and described in a way which addresses the problems noted and meets the stated objectives. Thus, while the present invention has been discussed above in terms of the preferred embodiments of the invention and modifications thereof, the invention may be embodied in various ways. Therefore, any embodiments and modification thereof which are implemented without departing from the principal of the invention as defined in the appended claims are within the scope of the invention.

What is claimed is:

1. A paint apparatus for painting a device in a painting spry booth with a paint, comprising:

a painting spray booth in which said device can be placed for painting;

a portable tote for said paint, sized to have a relatively low volume sufficient under applicable regulatory codes regarding said paint for permitting a predetermined plurality of said totes to be collectively located within a factory in a relay room, whereby said relay room need not be an explosion proof space under said applicable regulatory codes when housing said plurality of said totes;

a circulating tank for directly receiving paint from said portable tote and also being sized to have a relatively low volume sufficient under said applicable regulatory codes regarding said paint for permitting a like plurality of circulating tanks to be collectively located within a space in a relay room, whereby said relay room need not be an explosion proof space under said applicable regulatory codes when housing said plurality of said circulating tanks;

automatic control means cooperating with said portable tote and said circulating tank associated with said portable tote for automatically and continuously controlling the volume of said paint within said circulating tank within predetermined volumetric limits; and

means for delivering said paint from said circulating tank to a predetermined number of drops in said painting spray booth for painting said device.

2. The painting apparatus as set forth in claim **1**, wherein said paint is a waterbased paint and said predetermined plurality of portable totes is determined by applicable codes regulating a quantity of paint which can be stored in said relay room.

3. The painting apparatus as set forth in claim **1**, wherein said device is an automotive vehicle which is painted by paint from said drops in said painting spray booth.

4. The apparatus as set forth in claim **3**, wherein said plurality of portable totes and said plurality of circulating tanks are located in the same relay room adjacent to said painting spray booth located in an assembly line in an automotive vehicle factory.

5. The apparatus as set forth in claim **1**, further including automatic monitoring means for automatically tracking the use of paint through the apparatus to an uninterrupted supply of paint to a high usage volume location of application in he painting spray booth from the low volume supply of the plurality of sources.

6. The paint apparatus as set forth in claim **5**, wherein said relay room housing both the circulating tanks and the totes having predetermined volumes is within said code limits for the volume of paint located in said relay room.

7. The paint apparatus as set forth in claim **1**, wherein paint from said totes and said tanks does not pass through hot areas of the painting system or a factory to said painting spray booth, thus obviating a need for temperature control for said paint.

8. An apparatus which includes:

a painting spray booth for painting an object from a plurality of paint drops located in said painting spray booth;

a plurality of paint totes having paint therein and located in a relay room adjacent said painting spray booth;

a like plurality of circulating tanks also located in said relay room adjacent said totes for directly receiving a volume of paint from said totes, the volume of paint in said totes and said circulating tanks in said relay room being within code limits for limiting the amount of said paint stored within said relay room;

said painting spray booth having a plurality of paint drops positioned relative to the passage of an automobile body therethrough to paint said body, said paint booth being located adjacent said relay room;

a plurality of pipes respectively connected to said circulating tanks and traversing a side of said booth at a location below the level of said vehicle passing through said booth, said supply pipes passing beneath an end of said booth, and a plurality of return lines to said circulating tanks; and

automatic means for automatically monitoring flow of paint from said tote to said circulating tank and to said painting spray booth, including means for controlling volume of said paint in said circulating tanks.

9. The apparatus as set forth in claim **8**, wherein said automatic means further includes means for controlling the volume of paint in each of said circulating tanks to within a predetermined limit so that a relatively low volume of paint supply in said circulating tanks services a predetermined relatively high demand for usage in said paint booth.

10. The apparatus as set forth in claim **9**, further including means responsive to said monitoring means for providing a signal indicative of a low volume of paint remaining in said totes for replacement of said totes.

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